

MONROE RESERVOIR
Monroe and Brown Counties
2007 Largemouth Bass Population Estimate

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EXECUTIVE SUMMARY

- Monroe Reservoir is a 10,750-acre flood control reservoir in Brown and Monroe Counties southeast of Bloomington, Indiana. It is the largest lake in the state and recreational activities such as boating, fishing and hunting are very important. Monroe Reservoir also serves as the primary water supply for the City of Bloomington. Largemouth bass are the primary game species at Monroe Reservoir. Because of the size of the reservoir, a largemouth bass population estimate has never been attempted until 2007.
- A stratified random sampling approach incorporating the Schnabel mark and recapture method was used to estimate the largemouth bass population at Monroe Reservoir. The two strata were divided by the State Highway 446 causeway. Population estimates were calculated by stratum and added together to produce the total population estimate.
- In addition, another study to determine if bass were moving in and out of the sample stations was conducted. Bass were marked with numerically specific Floy® T bar tags outside the sample stations. Throughout the population estimate sample crews were to document Floy® tagged bass. Equal numbers of bass marked with fin clips were collected outside the sample sections as were Floy® tagged within the sample station, indicating bass migration was not an issue.
- The largemouth bass population estimate for the upper stratum was 6,653 fish. The population estimate for the lower stratum was 16,143 bass. The total largemouth bass population estimate for Monroe Reservoir was 22,797 bass 8 in TL and greater.
- Bass collected ranged from 3.2 to 23.3 in TL. The PSD was 59, RSD15 was 31 and RSD20 was 3 (Anderson and Neumann 1996). Growth for bass is very good with bass reaching legal size by age 4. Growth and stock densities were similar to Monroe bass sampling in 2003 and 2005.
- Bass tournament catch records are reported annually. In 2007, 30 bass tournaments reported their results. A total of 2,636 anglers spent 23,609.5 h competitively fishing for bass at Monroe. There was a total of 2,435 bass caught for a catch rate of 0.10 bass/h.
- Bass condition, based on relative weights, indicates Monroe bass are in excellent condition and are not forage limited.

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INTRODUCTION

Monroe Reservoir is a 10,750-acre flood control reservoir in Brown and Monroe Counties southeast of Bloomington, Indiana. It is the largest lake in the state, and recreational activities such as boating and fishing are very important. Boat access is available at ten publicly-owned ramps located around the lake. In addition, several privately-owned recreational facilities such as boat rentals, sport shops, marinas, and campgrounds are available. Monroe Reservoir also serves as the primary water supply for the City of Bloomington.

At normal pool, the maximum depth of Monroe Reservoir is 54 ft with an average depth of 25 ft. The water level is regulated by the Corps of Engineers and is relatively stable, but may fluctuate up to 17 ft depending on storage needs. The lake is divided into two distinct basins which are separated by the State Road 446 causeway. The upper basin receives 90% of the runoff entering the lake and is shallower and more turbid than the lower basin. During summer, oxygen concentrations in the lower basin are usually adequate for fish survival down to depths of 16 to 20 ft. In the upper basin, adequate oxygen is normally present to a depth of about 12 ft (Kittaka 2008).

Since impoundment in 1965, Monroe Reservoir has been managed primarily for largemouth bass and panfish fishing. A 14-in minimum size limit on largemouth bass has been in effect since 1973. As often occurs in new reservoirs, Monroe provided excellent fishing for several years after impoundment. Fishing quality began to level off as the reservoir aged, accompanied by increases in numbers of less desirable species such as yellow perch, yellow bass, and gizzard shad. In the early 1980s, the lake's fish community had been characterized by an overabundance of forage fish and too few predator fish. Since the mid-1980s, walleye and hybrid stripers have been stocked to utilize the abundant forage and provide additional fishing opportunities (Schoenung 2002).

Largemouth bass have been the primary games species at Monroe Reservoir as documented in the past two angler creel surveys in 2000 and 2007. Because of the size of the reservoir, a largemouth bass population estimate has never been attempted until 2007. The objective of this survey was to determine the largemouth bass population size by number, document length frequency, age, growth structure, and mortality of the largemouth bass population. Mandatory fish tournament monitoring is also reported annually. The results of the 2007 reported bass tournaments at Monroe Reservoir will also be analyzed.

METHODS

The bass population estimate of Monroe Reservoir began on April 23 and ran to May 15, 2007. All largemouth bass were collected by Smith Root VI A® DC pulsed electrofishing boats. Because of the lake's size, a comprehensive shoreline mark and recapture population estimate was not possible. Sub-sample population estimates were conducted and expanded to the entire lake. A stratified random sampling approach incorporating the Schnabel mark and recapture method was used to estimate the largemouth bass population at Monroe Reservoir. This method was piloted at Sullivan Lake in Sullivan County in 2006 and was determined to be a viable method of conducting a bass population estimate when the lake size and personnel constraints are an issue (Kittaka 2007). The target shoreline coverage was approximately 50%-60% of the shoreline (Figure 1). Monroe is divided into two distinct areas which are separated by the State Road 446 causeway. Available habitat and water quality are limnologically distinct. Because of this, the population estimates were calculated independently from upper and lower strata. Effort for the lower stratum consisted of five electrofishing boats sampling 30 mi of shoreline south of the Hwy 446 causeway. This represented 50% of the available shoreline mi. Effort for the upper stratum was four electrofishing boats sampling 24 mi of shoreline above the causeway. This represented 66% of the available shoreline. All largemouth bass were collected and measured to the nearest 0.1 in TL. Largemouth bass were marked by removing the left pectoral fin.

A standard mark and recapture population estimate generally accounts for the total shoreline over the course of the survey. At Monroe this was not the design. Independent bass population estimates were calculated for each sample section. The methodology was tested at Sullivan Lake in 2006 (Kittaka 2007). A recommendation from the Sullivan Lake estimate was to quantify emigration vs. immigration at the sampling sites. To answer this question, bass were collected at the beginning of the mark and recapture survey at sites adjacent to the sampling sections. These fish were marked with Floy® T bar tags. Fin-clipped bass at this time were also documented and tagged. Tagged bass were to be documented during the population estimate to determine the rate bass were moving into the sample section.

The actual mark and recapture portion of the survey was scheduled for 3 to 4 runs or weeks beginning in mid-April. Water temperatures and lake levels were monitored to determine

when the survey would begin. It was determined that if the lake level reached 8 ft above normal pool, the water level would be too high to effectively electrofish the shoreline. The target for each station was a minimum of three mark and recapture runs and a standard error (SE) for each station of 10% or less. If at least three runs were conducted and SE was greater than 10%, the survey could end if declining catches due to rising water temperatures or lake levels increase or decrease the sample area.

Each stratum was calculated separately to estimate the bass population. The sum of the sample sections was averaged. The average number of bass per section was multiplied to the total number of possible sample sections in each stratum. This product represented the population estimate for each stratum. The two strata were then added to produce a total population estimate for Monroe Reservoir.

In order to increase efficiency of the sampling crews, all largemouth bass age data were collected one week prior to the mark and recapture portion of the survey on April 15 and 16, 2007.

Stock density indices were calculated for all the bass collected during the population estimate (Anderson and Neumann 1996). Otoliths were extracted to accurately determine age on a sub-sample of bass collected. Age data was fitted to the bass length frequency by an age-length key (Appendix). Total annual mortality estimate was obtained by a catch-curve analysis (Figure 1) (Ricker 1975). Fisheries Analysis and Simulation Tools (*FAST*) modeling was used to determine natural mortality (Slipke and Maceina 2000). Exploitation was calculated from an analysis of age structure as well as angler creel data.

TOURNAMENT MONITORING

Fishing tournaments at Monroe Reservoir are regulated by the Division of Fish and Wildlife permit system. Mandatory reporting of tournament data include; number of participants, total hours fished, total number and weight of fish at weigh-in and weight of winning "big fish". Measuring fish at weigh-in, to the nearest 1/2 in TL, was optional.

RESULTS

A total of 4,179 largemouth bass was collected and marked. There were 629 recaptures (Table 1). There was an average of 1,614 bass per station in the lower stratum. The lower

stratum was based on 10 stations or 60 mi. The estimated bass population for the lower stratum was 16,143 fish. The average bass per station for the upper stratum was 1,109 fish. The upper end had six possible stations. The estimated population for the upper stratum was 6,653 largemouth bass. The total bass population estimate for Monroe Reservoir was 22,797 fish, 8 in TL and greater. Standard error for the population estimate was 8% with an upper 95% confidence interval (CI) of 26,639 and a lower CI of 19,954 (Table 2). By section, the lower stratum had higher fish per mi estimates than the upper stratum. Water clarity and available habitat appeared to be better suited for bass in the large incoming creek arms. At the time of sampling, the lake was 6 ft above summer pool and much of the terrestrial grasses and woody vegetation were partially or in some cases fully submersed. Sample sections on the main lake had sparse cover by comparison and resulting catches reflected it.

A total of 99 bass were marked with numerically specific Floy® T bar tags. There were 54 bass tagged in the lower stratum and 45 in the upper stratum. All of these fish were collected outside the population estimate stations. There was one bass in each stratum that was tagged that had a fin clip mark, indicating these fish moved out of the sample areas. The following week, during the population estimate, there was only one bass in each stratum that was marked with Floy® tags. It was concluded that there was little to no movement of fish in and out of the sample sites. Migration of bass does not appear to be an issue for these large sample sites.

The length range of the bass collected was 3.2 to 23.3 in TL. The PSD was 59, RSD15 was 31 and RSD20 was 3 (Anderson and Neumann 1996). This is similar to stock densities generated from bass surveys in 2003 and 2005 (Appendix).

Growth for largemouth bass was very good. Monroe bass reach legal size by age 4. Fish up to age 12 were collected. Growth when compared to spring 2003 and 2005 bass surveys was similar.

Total annual mortality estimates were obtained by catch-curve analysis (Ricker 1975). Total annual mortality for bass is 41%, with 95% upper and lower confidence intervals of 53% and 27%, respectively (Figure 2). The conditional or annual natural mortality rate, based on maximum age of fish observed and the proportion of fish surviving to that age, was estimated using FAST software. Annual natural mortality was 36%. Angler exploitation was calculated two ways in order to verify results. Exploitation based on subtracting total annual mortality from total annual natural mortality was 5%. Based on estimated bass harvest from the 2007 angler

creel survey and the bass population estimate, the exploitation rate was 4.1% of the bass population 14 in TL and greater.

TOURNAMENT MONITORING

Monroe Reservoir has been a popular tournament lake since the beginning of the permit process. In 2007, 30 bass tournaments reported their results. A total of 2,636 anglers spent 23,609.5 h participating in the reported tournaments. There was a total of 2,435 bass caught by tournament anglers for a catch rate of 0.10 bass/h. A total of 5,840.7 lbs of bass were weighed in for an average weight of 2.4 lbs per bass. Bass at this weight in the general survey were 16 to 16.5 in TL. The weight of the biggest bass was also reported. Anglers won “Big Bass” with bass as small as 2.1 lbs and as large as 7.1 lbs. The average weight of the “Big Bass” for 2007 was 4.9 lbs. Monroe Reservoir is also home for several catfish and crappie tournaments.

DISCUSSION

The 2007 bass survey is the first time a mark and recapture population estimate has ever been conducted at Monroe Reservoir. The stratified random sample design was first tested in Indiana in 2006 at Sullivan Lake, Sullivan County (Kittaka 2007). The design of this method was tested against the Lenape Lake, mark and recapture population estimate that included full shoreline samples (Schoenung 2003). Six different trials were run where 40% of the sample sites were randomly removed. The remaining 60% of the samples were expanded to encompass the entire shoreline. The expanded population estimates all fell within the standard error of the original estimate. One recommendation from the Sullivan Lake population estimate was to designate the stations by length rather than on-time shocking. Longer stations would reduce the amount of fish crossing in and out of the stations. This was evident when equal numbers of fin clipped fish were captured outside the sample stations as Floy tagged fish inside the sample sites. Only four bass moved in or out of the stations, also indicating little movement. The target standard error for a mark and recapture population estimate is 10%. Overall standard error for the Monroe estimate was 8%.

Bass estimates ranged from a high of 2,080 bass per section to a low of 841 bass per section. Aquatic vegetation at Monroe is relatively low. The annual fluctuations in water levels make it difficult to consistently establish aquatic vegetation habitat. The large incoming stream

channels like Moores, Allens, and Ramp Creeks have a variety of substrates and woody debris. These areas provide year round habitat under all seasonal conditions and as a result had higher population estimates. Section 2 had the lowest estimate below the causeway. This station had miles of sand and rock substrate with sporadic woody debris as the primary habitat. The upper stratum on average had lower estimates per section. Stations above the Hwy 446 causeway warmed up quicker than the lower end and also were much more turbid, making it difficult to collect bass.

Since 2001, bass catch rates have been approximately 50 bass/h. Since the station length was determined by shoreline mi and not time, catch per hour rates were not calculated. However, catch per hour rates were calculated while collecting bass for age and growth data and during the general survey. Catch rates were similar to past surveys with 56 bass/h for age data collection and 47 bass/h for the general survey.

Bass growth is very good at Monroe. Bass reach legal size by age 4. Bass condition was calculated based on weights taken during the general survey in 2007. Based on relative weights, largemouth bass at Monroe are in excellent condition (Kittaka 2008). The bass growth and catch rates have been consistent since 2003 indicating a stable bass population. The bass population estimate will provide baseline population information for future trend analysis of Monroe Reservoir.

Catch and release has become so popular that bass harvest data from creel surveys accounts for a small proportion of the bass population. Anglers were asked if their released bass were greater than or less than 14 in TL. This is the maximum level of accuracy one can expect from the general angling creel survey. Bass tournament reporting and monitoring may be an area where anglers and biologists can work together annually to monitor bass trends. Tournament coordinators are expected to maintain a level of accuracy often not found in general creel questions. The reporting requirements, at minimum, are what the tournaments collect to determine the outcome of their events. Additional information like individual lengths of bass is optional. Catch per effort data remains consistent and as long as the tournament organizers remain accountable for their programs the data should be accurate.

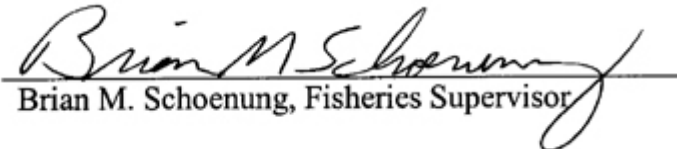
RECOMMENDATIONS

- Fishing tournament database for Monroe Reservoir should be maintained to monitor target species CPUE trends as well as angler participation.

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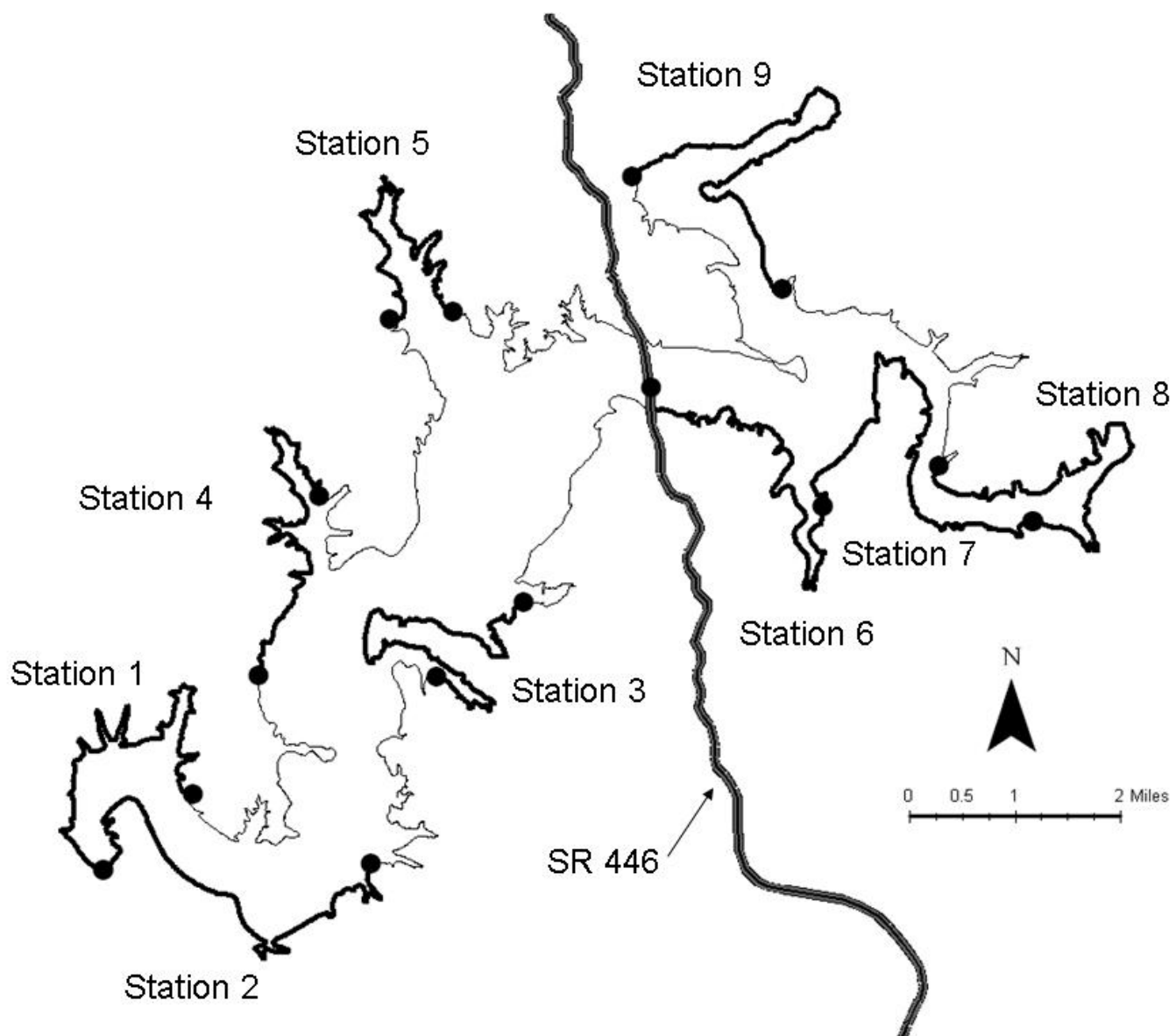
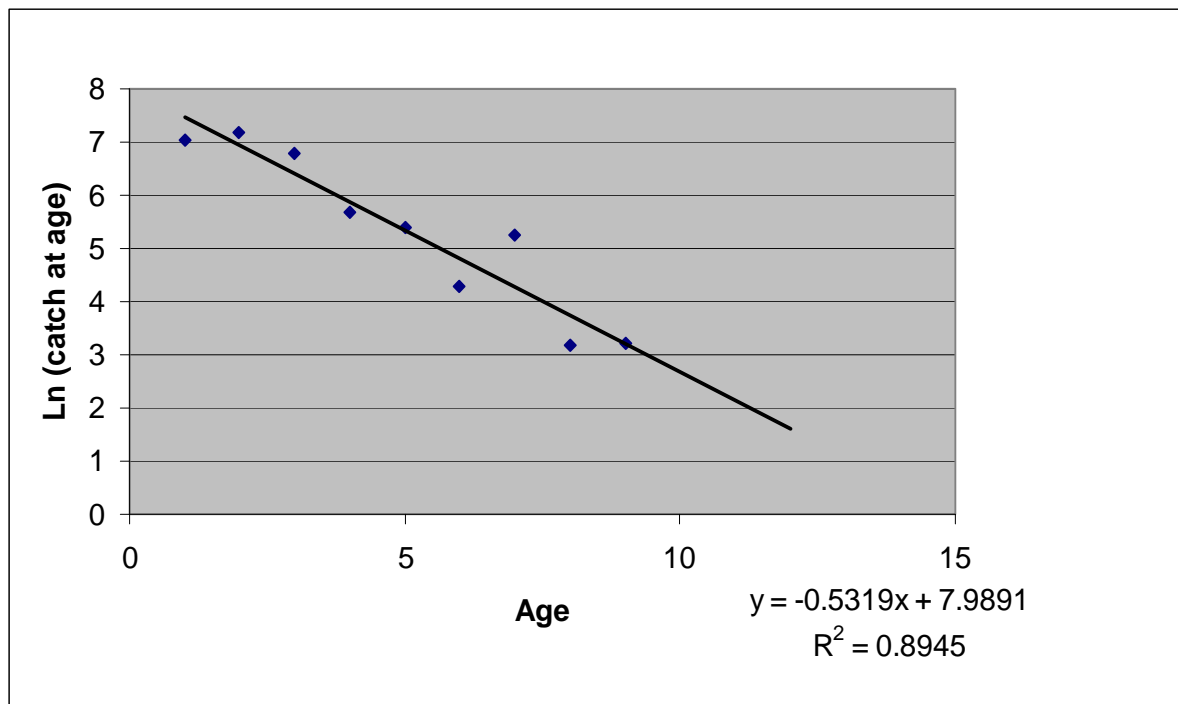


Figure 1. Largemouth bass sample stations, Monroe Reservoir, 2007.



Total Annual Mortality 0.41

95% Confidence Interval Upper 0.53 and Lower 0.27

Figure 2. Catch curve age analysis for Monroe Reservoir largemouth bass, 2007.

Table 1. Largemouth bass population estimates by sample section and stratum, Monroe Reservoir, 2007.

Lower Stratum	
Section	Estimated largemouth bass per section
1	1,438.36
2	1,149.32
3	2,080.56
4	1,583.53
5	1,820.18
Average bass per section 1,614.9	
Upper Stratum	
Section	Estimated largemouth bass per section
6	1608.39
7	858.44
8	1127.56
9	841.38
Average bass per section 1,108.94	

Table 2. The expanded largemouth bass population estimates by stratum, total number and standard error for Monroe Reservoir, 2007.

Lower stratum	Upper stratum	Total bass estimate	Lower 95% Confidence interval	Upper 95% Confidence interval	Standard error	% Standard error
16,143.90	6,653.65	22,797	18,954.11	26,639.88	1,921.44	8.0

APPENDIX

Monroe Reservoir Growth Summaries

Monroe Reservoir Largemouth Bass Length Frequency, 2007

Monroe Reservoir Largemouth bass age-length-key, 2007

Mean Length at Age for Monroe Reservoir largemouth bass, 2003, 2005, and 2007.

Date:	4/29/2003	to	5/7/2003			
		Mean			Lo	Up
Age	Number	TL	Var	SE	95%CI	95%CI
1	1	4.3	0.00			
2	169	8.9	1.17	0.08	8.7	9.0
3	186	12.6	2.08	0.11	12.4	12.8
4	84	15.0	2.33	0.17	14.6	15.3
5	39	17.2	0.68	0.13	17.0	17.5
6	10	18.5	0.68	0.26	18.0	19.1
7	12	19.2	0.83	0.27	18.7	19.7
8	8	19.9	1.13	0.37	19.2	20.6

Date:	4/23/2005	to	5/3/2005			
		Mean			Lo	Up
Age	Number	TL	Var	SE	95%CI	95%CI
1	24	4.8	0.46	0.14	4.5	5.1
2	81	8.0	0.97	0.11	7.8	8.2
3	99	10.1	0.71	0.08	9.9	10.2
4	80	13.2	0.59	0.09	13.1	13.4
5	70	15.8	1.49	0.15	15.5	16.1
6	25	19.2	1.01	0.20	18.8	19.6
7	3	21.3	0.00			

Date:	4/1/2007	to	5/1/2007			
		Mean			Lo	Up
Age	Number	TL	Var	SE	95%CI	95%CI
1	449	5.94	0.45	0.03	5.88	6.00
2	1128	9.54	0.98	0.03	9.48	9.60
3	1322	11.99	1.19	0.03	11.93	12.05
4	898	14.74	1.13	0.04	14.67	14.81
5	292	16.75	0.49	0.04	16.67	16.83
6	221	18.00	0.32	0.04	17.92	18.08
7	72	19.25	0.00	0.00	19.25	19.25
8	189	19.06	0.73	0.06	18.94	19.19
9	24	18.25	0.00			
12	25	20.25	0.00	0.00	20.25	20.25

NUMBER, PERCENTAGE, WEIGHT, AND AGE OF Monroe Reservoir Largemouth bass 4/23 - 5/16, 2007									
TOTAL LENGTH (inches)	NUMBER COLLECTED	PERCENT OF FISH COLLECTED	AVERAGE WEIGHT (pounds)	AGE OF FISH	TOTAL LENGTH (inches)	NUMBER COLLECTED	PERCENT OF FISH COLLECTED	AVERAGE WEIGHT (pounds)	AGE OF FISH
1.0		0.0			19.0	72	1.5		7
1.5					19.5	67	1.4		8
2.0					20.0	49	1.0		8,12
2.5					20.5	36	0.8		Not aged
3.0	2	0.0		1	21.0	20	0.4		Not aged
3.5	12	0.3		1	21.5	8	0.2		Not aged
4.0	24	0.5		1	22.0	7	0.1		Not aged
4.5	53	1.1		1	22.5				
5.0	71	1.5		1	23.0	2	0.0		Not aged
5.5	94	2.0		1	23.5				
6.0	113	2.4		1	24.0				
6.5	118	2.5		1	24.5				
7.0	66	1.4			25.0				
7.5	63	1.3		1	25.5				
8.0	105	2.2		1	26.0				
8.5	184	3.8		1	TOTAL	4795	100.0		
9.0	233	4.9		1					
9.5	259	5.4		2,3					
10.0	225	4.7		2,3					
10.5	227	4.7		2,3					
11.0	230	4.8		2,3					
11.5	246	5.1		2,3					
12.0	231	4.8		3,4					
12.5	263	5.5		3					
13.0	176	3.7		3					
13.5	170	3.5		3,4					
14.0	179	3.7		4					
14.5	172	3.6		4					
15.0	175	3.6		4,5					
15.5	150	3.1		5					
16.0	126	2.6		4,5					
16.5	131	2.7		5					
17.0	106	2.2		5,6					
17.5	125	2.6		5,6,8					
18.0	118	2.5		6,8,9,					
18.5	87	1.8		6,8					
ELECTROFISHING CATCH		NA /hr		GILL NET CATCH	NA /lift		TRAP NET CATCH		NA/lift

* Average weights derived from district averages

Lake: Monroe Reservoir
Date: 4/23/07 to 5/16/2007
Species: Largemouth bass

Length group (in)	Total number	Sub- sample	Age											
			1	2	3	4	5	6	7	8	9	10	11	12
3.0	2													
3.5	12													
4.0	24													
4.5	53	1	53											
5.0	71	4	71											
5.5	94	2	94											
6.0	113	3	113											
6.5	118	1	118											
7.0	66													
7.5	63	2		63										
8.0	105	2		105										
8.5	184	4		184										
9.0	233	5		233										
9.5	259	5		207	52									
10.0	225	7		96	129									
10.5	227	3		151	76									
11.0	230	4		58	173									
11.5	246	8		31	215									
12.0	231	3			154	77								
12.5	263	7			263									
13.0	176	3			176									
13.5	170	6			85	85								
14.0	179	6				179								
14.5	172	2				172								
15.0	175	5				140	35							
15.5	150	1				150								
16.0	126	8				95	32							
16.5	131	1					131							
17.0	106	4					53	53						
17.5	125	6					42	63		21				
18.0	118	5						47		47	24			
18.5	87	3						58		29				
19.0	72	2							72					
19.5	67	1								67				
20.0	49	2								25				25
20.5	36													
21.0	20													
21.5	8													
22.0	7													
22.5														
23.0	2													
Total	4795	116	449	1128	1322	898	292	221	72	189	24			25